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L4: Entry 7 of 13 File: USPT Feb 2, 1999

DOCUMENT-IDENTIFIER: US 5867411 A
TITLE: Kalman filter ionospheric delay estimator

Brief Summary Text (5):
Parameter estimators have been used to generate parameters estimates of parameters estimated from an input. Bias estimators have been used to generate bias esitmates of bias of an input. The parameter estimators and bias estimators are methods having many possible applications. One such application is range determination of the Gobal Positioning System (GPS) generating pseudoranges which are affected by potential bias, ionospheric propagation delays and phase ambiguities producing ranging errors. GPS receivers are used to acquire position on ground, in air or in space based upon the reception of satellite signals transmitted from the GPS satellite constellation. From the GPS satellite transmit antenna, the satellite signals propagate through free space, the ionosphere and the troposphere to the GPS receiver. The GPS constellation consists of 24 satellites operating in twelve-hour orbits at an altitude of 20,183 km and provides visibility of six to eleven satellites at elevations of five degrees or more above the horizon to users located anywhere in the world at any time. The navigation signals from the satellites consist of two rf frequencies, L.sub.1 at 1575.42 MHz and L.sub.2 at 1227.6 MHz. The L.sub.1 and L.sub.2 signals are modulated by pseudo-random noise (PN) or spread-spectrum (SS) codes and are also modulated with the navigation data-stream at 50 bps carrying various navigation messages. The signals transmitted from different satellites occupy the same rf bandwidth on a Code Division Multiple Accessing (CDMA) basis. In the CDMA techniques, different PN codes are assigned to different satellites and the receiver matches these codes with like reference codes generated in the receiver through cross-correlation technique implemented in Delay Lock Loops (DLLs). Individual DLLs are assigned to different satellites being tracked by the receiver in a parallel approach or a single loop is shared in a time division mode among many satellites in a single channel and less expansive receivers. In addition to making it possible to separate signals from different GPS satellites, the PN codes also make it possible to measure the range to the satellite by measuring the signal propagation delay from the satellite to the GPS receiver by measuring the relative phase of the received signal code phase with the local reference code phase. The accuracy with which such a propagation delay can be measured depends upon the PN code chip rate, the latter directly determining the rf bandwidth of the spread spectrum modulated signal. The measurement accuracy of the propagation delay is equal to a fraction of the PN code chip period, that is, the inverse of the code chip rate. The actual fraction depends upon the various details of receiver implementation and various sources of errors. Each GPS satellite has two codes assigned to it, a distinct C/A code with a chip rate of 1.023 MHz and a P-Code with different offsets and with a chip rate of 10.23 MHz. The L.sub.1 signal is modulated with both the P and C/A codes in phase quadrature and the L.sub.2 signal is modulated with the P-Code.

Detailed Description Text (5):
The bank of Kalman filters 16 is used to resolve ambiguities. In the state space formulation, x (k) represents the state vector at the kth update discrete time interval. The range equations may be rewritten in compact form by an x (k) vector definition state equation, a z(k) vector measurement state equation, a z(k) vector measurement definition state equation and a vector observation noise definition.

state equation all four of which are collectively referred to as state equations which use an H matrix defined by an H Matrix equation. ##EQU2##

Detailed Description Text (26):
In the presence of bias, the z (k) vector measurement equation is replaced by a modified observation vector equation using a b matrix equation.

Detailed Description Text (27):
Observation Vector Equation